CLAIMS

1. A phase-shifter comprising: phase-altering means for introducing a phase shift into a signal whose phase is to be controlled and an actuator (20)which changes shape in response to an electrical control signal, wherein the actuator is mechanically connected to the phase-altering means such that the change in shape of the former leads to a phase-altering action in the latter; characterised in that the actuator comprises a tubular stator (22) of piezoelectric or magnetostrictive material; a piston (26) coaxially disposed within the stator and a bearing member (24) disposed between the stator (22) and piston (26), wherein the stator (22) distorts in an approximately frustro-conical manner in response to said control signal thereby causing the bearing member (24) to roll axially along the stator(22), the movement of the bearing member (24) in turn causing axial movement of the piston (26).

2. A phase-shifter according to Claim 1 in which the stator comprises a piezoelectric tubular member (22) having an electrode structure (23, 25) on its internal and external curved surfaces for coupling to a source of the control voltage and the bearing member (24) is an elastically deformable member of approximately annular cross-section.

3. A phase-shifter according to Claim 1 or Claim 2 in which the stator has a slot (30) extending completely through the wall (28) of the tubular member (22) and which describes a helical path about the tubular member (22).

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4. A phase-shifter according to any preceding claim in which the phase-altering means comprises a reflecting member (34) attached to the piston (26), the reflecting member (34) being disposed inside a waveguide arrangement (38, 40), whereby application of a control voltage to the actuator (20) causes the reflecting member (34) to move inside the waveguide arrangement (38,40), thereby altering a path length of a signal propagated along the waveguide arrangement.

5. A phase-shifter according to Claim 4 in which the waveguide arrangement comprises first (40) and second (38) parallel waveguides, the waveguide cavities communicating (44) with each other over at least a part of their common length, the first waveguide (40) containing a radiating element (48) for producing radiation to be propagated along the first waveguide (40) toward the reflecting member and the second waveguide having a radiating aperture (50), wherein, in use, radiation propagating in the first waveguide (40) is reflected from the reflecting member (34) into the second waveguide (38) and out through the radiating aperture (50).

6. A phase-shifter according to any one of Claim 1 to 3 in which the phase-altering means comprises a waveguide (54; 72) containing one or more dielectric slabs (56; 74) made of a material of a first dielectric constant fixed to the waveguide and a movable dielectric slab (58; 76) made of a material of a second dielectric constant disposed in co-operating relationship with the one or more fixed slabs (56; 74), the movable slab (58; 76) being connected to the piston (26; 73).

7. A phase-shifter according to Claim 6 in which the one or more fixed slabs (56) are secured to an inside surface of the waveguide wall and define a laterally substantially central cavity free from dielectric material, and wherein the movable slab (58) is arranged to be axially movable within said substantially central cavity.

8. A phase-shifter according to Claim 7 in which the waveguide (54) is attached to one end of the actuator stator (22) and the movable dielectric slab (58) is connected to the piston (26) by means of a push rod (60).

9. A phase-shifter according to Claim 7 in which the piston (73) is hollow and the waveguide (72) is disposed in the piston.

10. A phase-shifter according to Claim 9 in which the movable dielectric slab (76) is connected to the piston (73) by means of connecting arms (70) projecting radially inwardly from the piston (73) and locating inside axially oriented slots (71) provided in the waveguide (72) wall and in one or more of the fixed dielectric slabs (74).

11. A phase-shifter according to any one of Claims 6 to 10 and further comprising a launcher (62) is provided in the waveguide wall at a location not occupied by the fixed (56; 74) or movable (58; 76) dielectric slabs, the launcher (62) serving to generate a wave which passes through the slabs and out through a radiating aperture of the waveguide.

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12. A phase-shifter according to any one of Claims 6 to 11 in which said first dielectric constant is approximately the same as said second dielectric constant.

13. A phase-shifter according to any one of Claims 1 to 3 in which the phase-altering means comprises a dielectric gel (86) contained within a waveguide (54).

14. A phase-shifter according to Claim 13 in which the dielectric gel (86) is contained within a bag (80), an outer surface of which is attached to an inner surface of a wall of the waveguide (54), and a transversely central end-portion of which is connected to the piston (26).

15. A phase-shifter according to Claim 14 in which the piston (26) is attached to the bag (80) by way of a movable dielectric slab (76).

16. A phase-shifter according to Claim 15 in which the movable slab (76) and the gel (86) have approximately the same dielectric constant.

17. A steerable phased array antenna, comprising an input to supply a signal to the array, a splitter (12) to split the signal into a plurality of sub-signals (13) and a plurality of antenna elements (15) to transmit the sub-signals, the antenna elements (15) having associated phase-shifting means (14) to phase-shift the sub-signals (13) so that the array transmits the signal steered in a chosen direction; characterised in that each of the phase-shifting means (14) comprises

a phase-shifter according to any preceding claim.

18. A steerable phased array antenna according to Claim 17 and further comprising a power amplifier (11) connected between the input supplying the signal to the array and the splitter (12).

19. A steerable phased array antenna comprising a plurality of receiving antenna elements (15) having associated phase-shifting means (14) to phase-shift the signals supplied by the antenna elements(15) and a combiner (12) connected to the phase-shifting means (14) to combine the phase-shifted signals, characterised in that the phase-shifting means (14) comprises a phase-shifter according to any one of Claims 1 to 16.

20. A steerable phased array antenna according to Claim 19 and further comprising a plurality of amplifiers (16) connected between respective phase-shifting means (14) and the combiner (12).

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